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SPECIAL RE-REVIEW
FINAL DETERMINATION
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By: J.P. Deroquin DATE 6-30-81
By: J.W. Jordan 6-30-81
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April 19, 1955

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ROUTINE UR PLANT STRONTIUM SCAVENGING WITH $Ca(NO_3)_2$

During the past month, on the basis of encouraging Process Chemistry Unit results, tests have been conducted in the UR Plant in an attempt to improve strontium 90 scavenging by the addition of calcium nitrate to the ferrocyanide scavenged waste. These tests indicated that calcium nitrate (waste concentration 0.016 M) added to the scavenged waste at 90 C improves the strontium scavenging three to six fold, provided the pH is controlled in the range of eight to ten. Since these tests demonstrate that the addition of calcium improves the strontium DF, and since preliminary soil column tests indicate no adverse soil adsorption effects, it is recommended that sufficient calcium be routinely added to the UR Plant waste at at temperature of 90 C in tank 9-7 (concentrated waste receiver) to produce a 0.016 ± 0.003 M calcium concentration in the dilute waste.

Discussion

Laboratory Studies

The Process Chemistry Laboratory has completed several studies over the past two months, aimed at improving strontium 90 scavenging. These studies were performed using actual UR Plant acid waste and show that increased $K_4Fe(CN)_6$ and $NiSO_4$, or Fe^{++} concentrations, or isotopic dilution of strontium do not give any significant improvement in strontium 90 removal. On the other hand, studies, using calcium as a supplemental scavenging agent, show that calcium will lower the residual strontium 90 concentrations. A summary of the laboratory data is listed below:

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April 19, 1955

Use of Calcium to Remove Sr^{90}

Conditions: (1) Acid waste composition, $PO_4^{\equiv}$, 0.12 M
Na^+, 3.4 M
Sr^{90}, 55 μc/ml

(2) Acid waste was butted to 0.005 M $K_4Fe(CN)_6$, then neutralized and butted to 0.005 M $NiSO_4$. $Ca(NO_3)_2$ was then added to the waste, with results as follows:

Final Concentration			
Ca^{++}, M	Sr^{90}, μc/ml	pH	Temperature, °C
0.00 (control)	3.0	9.0	30
0.001	2.69	9.0	30
0.002	1.96	9.0	30
0.004	1.08	9.0	30
0.008	0.71	9.0	30
0.016	0.36	9.5	30
0.03	0.25	9.5	30
0.03	0.07	9.4	90
0.03	0.47	7.8	90

Plant Studies

These laboratory studies were supplemented by three UR Plant tests conducted in tank 4-6 (batch size was 11,500 gallons). The results of the plant tests are summarized below and show that strontium 90 decontamination is aided by the addition of calcium, provided the pH of the waste is controlled between eight and ten. At 90 C, a six fold improvement in removal of strontium was attained by the addition of calcium (final solution concentration 0.016 M). At 30 C, only a four to five fold improvement was attained. Volume measurements of the sludge that will be formed when calcium is added to the waste have not been made, but it is expected that the final volume of sludge (both ferrocyanide and calcium scavenger) formed will be between 10 and 15 volume per cent of the waste.

UR Plant
Calcium Test to Aid Removal of Strontium 90

Test Conditions

Calcium 0.016 M; batch size 11,500 gallons; waste was neutralized in tank 11-6, concentrated in 9-1, and nickel sulfate added to tank 9-7. The waste was then transferred to tank 4-6, where the calcium was added.

Test No.	Sample	pH	Sr^{90}, μc/ml	DF	Remarks
1	Before Ca	7.55	0.80		Room temperature 30 to 50 C
	After Ca	7.60	0.72	1.12	
	After Ca	7.90	0.71	1.12	pH adjusted to 8 after Ca

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Test No.	Sample	pH	Sr^{90}, μc/ml	DF	Remarks
2	Before Ca	9.3	5.44		Room temperature 30 to 50 C
	After Ca	9.2	1.72	3.15	
	After Ca	9.2	1.36	3.99	Sample settled an additional 24 hours
3.	Before Ca	8.8	4.91		Heated to 90 C before adding calcium
	After Ca	8.4	0.79	6.24	

Expected Plant Performance

From the above tests, a three to six fold improvement in the strontium 90 decontamination factor would be expected by the routine addition of 0.016 ± 0.003 M calcium to the concentrated UR Plant waste if the waste is held at 90 C and the pH is controlled between eight and ten.

With the improved pH control presently achieved in the primary scavenging operation and the three to six fold improvement which should result from calcium scavenging, it is expected that the strontium concentration of the supernatant will be reduced sufficiently (to less than 0.5 microcuries/ml) to insure routine cribbing.

Plant Operating Conditions and Equipment Changes

The calcium should be added to the waste after the waste evaporator to avoid possible calcium salt precipitation on the evaporator tubes. It is suggested that the calcium be added continuously to tank 9-7 (waste evaporator receiver) with the waste held at 90 C. The waste should be agitated continuously with a minimum volume in 9-7 of 3,000 gallons to insure good mixing of calcium, nickel sulfate, and waste. Laboratory studies indicate that the addition of calcium nitrate and nickel sulfate to the waste simultaneously, but through separate lines, will give satisfactory strontium 90 removal. Addition of calcium nitrate and nickel sulfate through a common line will cause the line to plug with calcium sulfate. In order to add the calcium nitrate solution to tank 9-7 from the X-09 scale tank, but not through the nickel sulfate addition line, a connection from the X-09 manifold to Cell 18, wall nozzle 60 must be installed, and in Cell 18, a new jumper is required from wall nozzle 60 to 9-7 tank nozzle G. (See Figure II for a sketch of new piping.)

The calcium nitrate solution can be prepared in the wash solution tank (203) by dissolving calcium carbonate (limestone) in 60 per cent nitric acid (ratio of 100 pounds of limestone for each 200 pounds of 60 per cent nitric acid). (Specific gravity vs weight per cent data in Figure I.) The calcium nitrate may be transferred to the X-09 scale tank after the wash solution header is connected to the X-09 scale tank chemical addition manifold. It is expected that the cost of the equipment modifications will not exceed $2,000.

Cost of Chemicals

On the basis of 0.016 M calcium and a waste volume of 9,200 gallons per ton of uranium processed, 115 pounds of calcium carbonate and 145 pounds of 100 per cent nitric acid

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will be used for each ton of uranium processed. These chemicals will cost about $6.70 for each ton of uranium processed, or $0.00073 per gallon of waste.

Soil Column Tests

Preliminary soil column tests using a sample of the calcium treated waste from the UR Plant Test No. 3 indicate that the presence of residual calcium in the scavenged supernatant has no adverse effects upon the soil adsorption of strontium.

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FIGURE 1

SPECIFIC GRAVITY OF $Ca(NO_3)_2$ SOLUTIONS AT 0°C
VERSUS WEIGHT PER CENT

(Vol. 3 International Critical Tables)

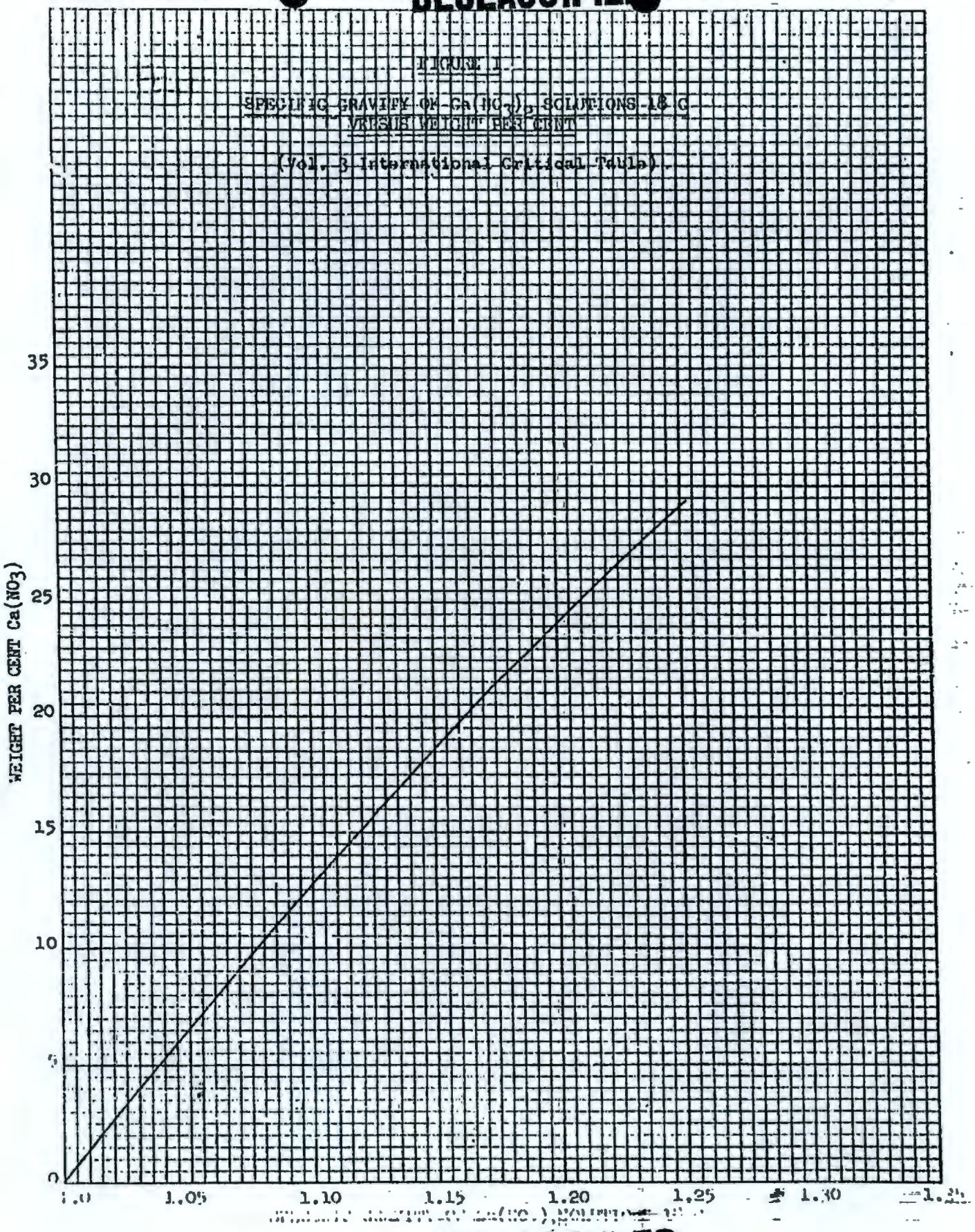

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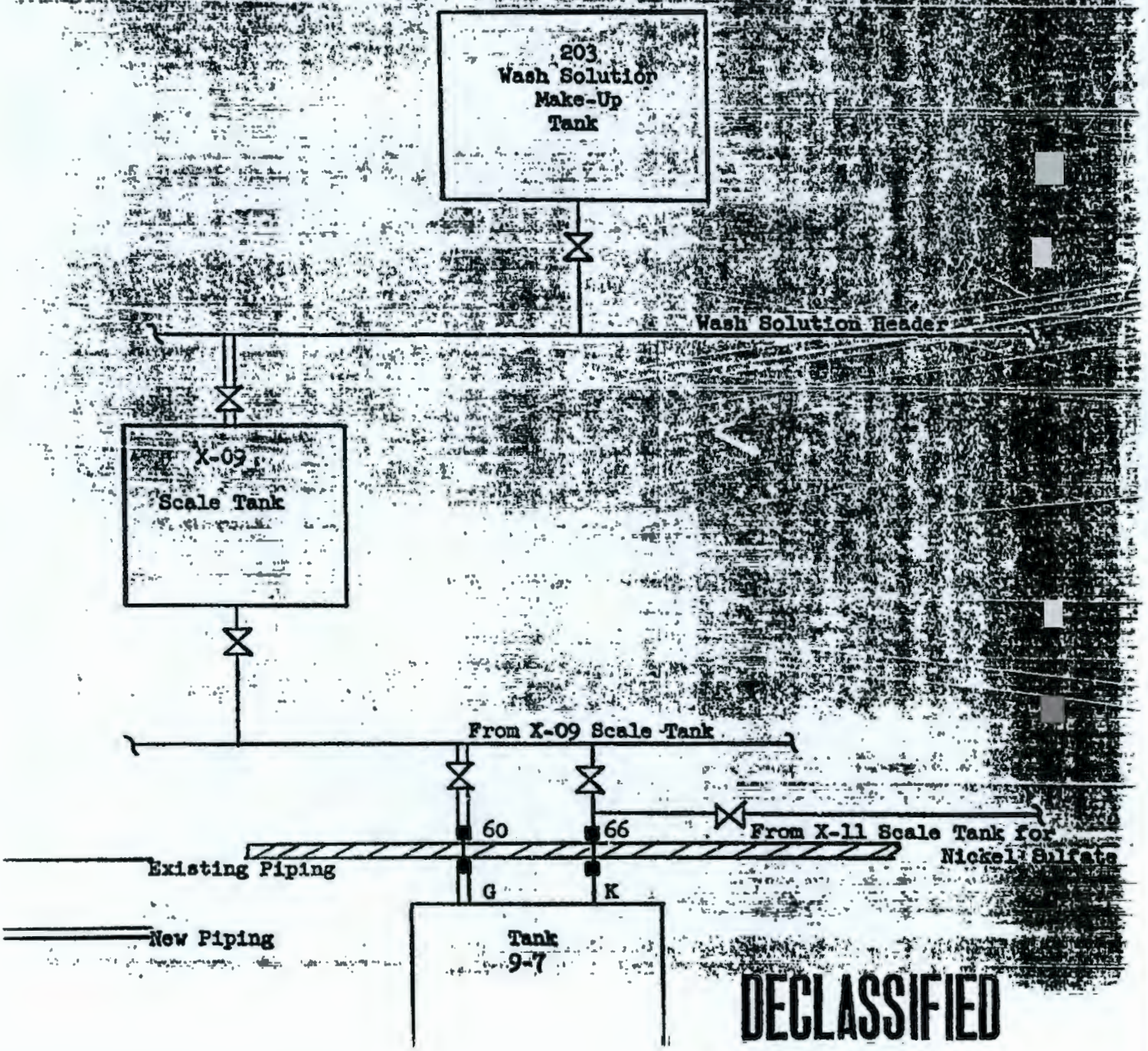
FIGURE II

FLOW DIAGRAM
ADDITION OF CALCIUM NITRATE TO SCAVENGED WASTE



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